Goddard Space Flight Center SPI

GSFC

Introduction to NASA Software Engineering Requirements (NPR 7150.2)

Presented by: Al Glass

Software Process Improvement (SPI) Project

Awareness Session
Purpose and Objectives

- **Purpose: Acquaint you with NPR 7150.2 requirements for software projects**
- **Objectives - After this session you should know:**
  - **That NPR 7150.2 requirements are mandatory based on software classification (i.e., Classes A – H)**
  - **How to find NPR 7150.2 online**
  - **How the NPR is organized**
  - **That a deviation request must be submitted and approved for requirements not implemented**
  - **What requirements NPR 7150.2 levies on projects**

But, before we start.....

NASA Software Classifications*

Classification	Charactеristics
A - Human Rated Software Systems	All space flight software subsystems (ground and flight) developed and/or operated by or for NASA to support human activity in space and that interact with NASA human space flight systems.
B - Non-Human Space Rated Software Systems	Flight and ground software that must perform reliably in order to accomplish primary mission objectives.
C - Mission Support Software	Flight or ground software that is necessary for the science return from a single (non-critical) instrument or is used to analyze or process mission data or other software for which a defect could adversely impact attainment of some secondary mission objectives or cause operational problems for which potential work-arounds exist.
D - Analysis and Distribution Software	Non-space flight software. Software developed to perform data collection, storage, and distribution; or perform engineering and science hardware data analysis.
E - Development Support Software	Non-space flight software. Software developed to explore a concept; or support software or hardware development functions suchdesign as requirements management, design, test and integration, configuration management, documentation, or perform science analysis.
F - General Purpose Computing Software (Multi Center or Project Use)	General purpose computing software used in support of the Agency, multiple Centers, or multiple programs/projects…
G - General Purpose Computing Software (Single Center or Project Use)	General purpose computing software used in support of a single Center or project…
H - General Purpose Desktop Software	Examples of Class H software include, but are not limited to, desktop applications such as Microsoft Word, Excel, and Power Point, and Adobe Acrobat.

***Refer to NPR 7150.2 for complete descriptions**

An Overview of NPR 7150.2

- **NPR 7150.2**
  - **provides a common set of generic requirements for software created and acquired by or for NASA**
  - **defines requirements for Software Engineering Management**
  - **is a stand-alone compendium of requirements to protect NASA's investment in software engineering products**
  - **states requirements in a form that are easily mapped to industry standards and proven NASA experience in software engineering**
  - **Includes "best practices" that may already be satisfied through existing programs, procedures, and processes**

NPR 7150.2 and CMMI®

- **Those of you who have been attending these awareness sessions or SPI workshops will recognize much of what is included in NPR 7150.2**
- **NPR 7150.2 works "hand in glove" with CMMI ®**
  - **You'll see much of the same terminology and required practices.**
  - **NPR 7150.2 requires compliance with CMMI ® for certain classes of software.**

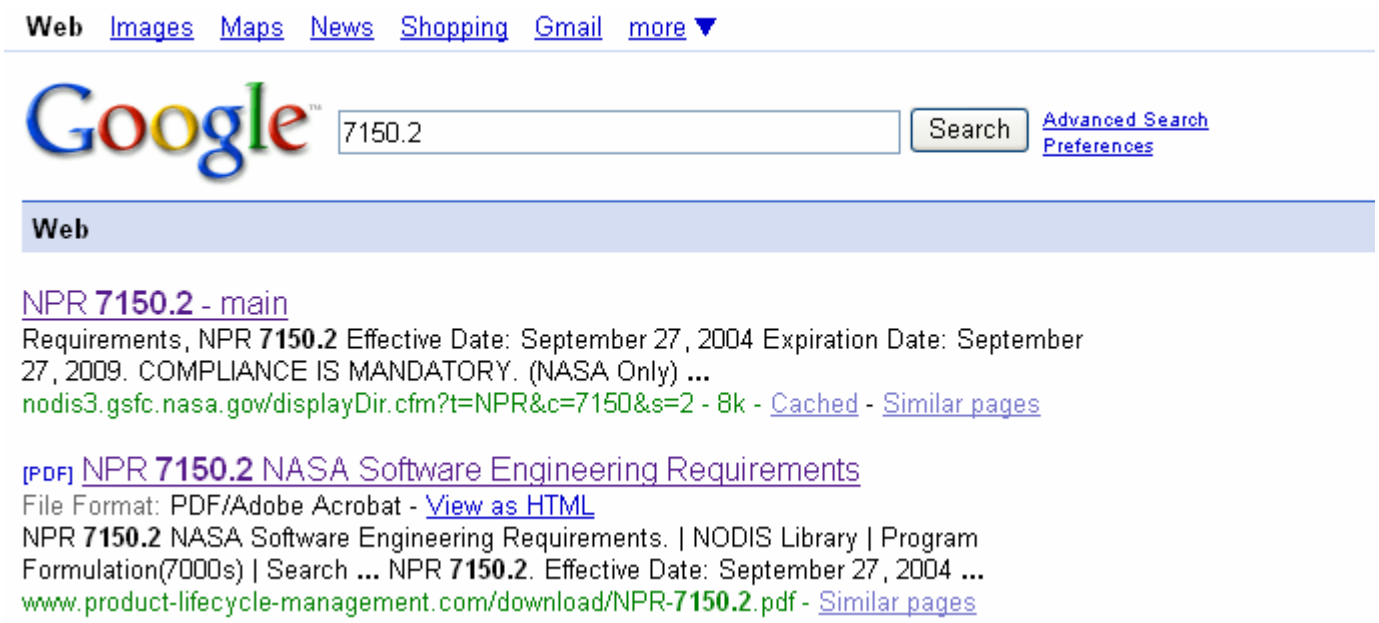
About the NPR

- The NASA Office of the Chief Engineer is responsible for the NPR
- The NPR is MANDATORY per section P2.3
  - "The NPR shall be applied to all software development, maintenance, operations, management, acquisition, and assurance activities"
- Requirements are levied on Center organizations as well as projects
  - Applicability of requirements is determined through the use of a NASA-wide definition of software classes
- To find the document online or just "Google 7150.2"
  - From NASA Online Directives Information System (NODIS) (http://nodis3.gsfc.nasa.gov/main_lib.html)
  - Search on "NPR 7150.2"

NPR 7150.2 and GSFC

- NPR 7150.2 requirements are in the process of being flowed down into Goddard's GPR's
  - one specifically for acquisition projects and a more general one.
- They are planned for release later this year.

Finding NPR 7150.2



Deviating From NPR 7150.2

- **Requests for waivers from NPR 7150.2 requirements must be submitted to the Independent Technical Authority (ITA) Warrant Authority**
  - **Some requirements may only be waived at HQ level (e.g. CMMI ® L2 requirement)**
- **The ITA Warrant Authority for this NPR considers the following when assessing waiver and variant requests:**
  - **The list of Agency projects containing software**
  - **The classification of systems and subsystems containing software as defined in Appendix B**
  - **Applicable Center-level software directives that meet the intent of this NPR**
  - **Applicable contractor and subcontractor software policies and procedures that meet the intent of this NPR**
  - **Potential impacts to NASA missions**

Contents of NPR 7150.2

Preface	**P.2 Applicability and Scope**
1 Introduction	**1.2 Organizational Capability and Improvement**
2 Software Management Requirements	**2.1 Compliance with Law** **2.2 Software Life Cycle Planning** **2.3 Commercial, Government, and Modified Off-The-Shelf Software** **2.4 Software Verification and Validation** **2.5 Project Formulation Requirements** **2.6 Software Contract Requirements**
3 Software Engineering (Life Cycle) Requirements	**3.1 Software Requirements** **3.2 Software Design** **3.3 Software Implementation** **3.4 Software Testing** **3.5 Software Operations, Maintenance, and Retirement**
4 Supporting Software Life Cycle Requirements	**4.1 Software Configuration Management** **4.2 Risk Management** **4.3 Peer Reviews/Inspections** **4.4 Software Measurement** **4.5 Best Practices** **4.6 Training**
5 Software Documentation Requirements	**5.1 Software Plans** **5.2 Software Requirements and Product Data** **5.3 Software Report Requirements**
6 Tailoring, Warrant Authority, and Compliance Measurement	**6.1 Tailoring of Requirements** **6.2 Expertise of ITA Warrant Authority(s)** **6.3 Compliance**
APPENDIX A: References	
APPENDIX B: Definitions	
APPENDIX C: Acronyms	
APPENDIX D: Requirements Mapping Matrix	

Here's what the document looks like: Download and review it!

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2.2 Software Life Cycle Planning

Software Life Cycle Planning covers the software aspects of a project from inception through retirement. It is meant as an organizing process that considers the software as a whole and provides the planning activities required to insure a coordinated, well-engineered process for defining and implementing project activities. These processes, plans, and activities are coordinated within the greater project. At project conception, software needs for the project are analyzed, including acquisition, supply, development, operation, maintenance, and supporting activities and processes. The software effort is scoped and the processes, measurements, and activities are documented in software plan(s).

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Responsibility is clearly defined

Note that the Requirements are numbered!

2.2.1 The project shall develop software plan(s). **[SWE-013]**

Note: The requirement for the content of each software plan (whether stand-alone or condensed into one or more project level or software documents) is defined in Chapter 5. These include, but are not limited to:

a. Software development or management plan.
b. Software configuration management plan.
c. Software test plans.
d. Software maintenance plans.
e. Software assurance plans.

2.2.2 The project shall implement and execute the software plan(s). **[SWE-014]**

2.2.3 The project shall establish, document, and maintain at least one software cost estimate that satisfies the following conditions: **[SWE-015]**

a. Covers the entire software life cycle.
b. Is based on selected project attributes (e.g., assessment of the size, functionality

NPR 7150.2 SW Engineering Requirements in a Nutshell

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Relevant SW Laws, Policies and Requirements:

SWE-007-012 Disclosure, Technology Transfer, External Release, Security, Disabilities

Start Up	Formulate, Classification & Acquisition Req.	SWE-020-021, 027, 032-042
Plan	Plans, Estimates, & Schedules	SWE-013-016, 037, 125
	Lifecycle & Stakeholder Reviews	SWE-018-019
	Assurance	SWE-022
	Safety	SWE-023
Monitor	Monitor, Track, & Control	SWE-017, 024-026, 043-048
Develop	Requirements	SWE-049-052
	Design	SWE-056-059
	Implementation	SWE-060-064
	Testing	SWE-065-073
	Requirements Management and Traceability	SWE-053-055, 052, 059, 064, 072
	Verification & Validation	SWE-028-031
	Operations, Maintenance, Retirement	SWE-074-078
Supporting Requirements	Configuration Management	SWE-079-085
	Risk Management	SWE-086
	Peer Reviews/Inspections	SWE-087-089
	Measurement	SWE-090-097
	Best Practices	SWE-098-099
	Training	SWE-100-101, 017

Chart Provided by Pat Schuler & Chuck Niles (LaRC)

7150.2 Requirement Mapping Matrix

- **Appendix D contains the complete Requirements Mapping Matrix**
  - **Used to determine which requirements apply based on Software Class (A, B, C, D, E, etc.)**

Section of NPR	Requirement Descriptor*	SWE Reqmt. No.	Responsibility	Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H
SW Life Cycle Planning	*SW Plan*	13	Project	X	X	X	P (Center)	P (Center)	X	P (Center)	
	Execute Plan	14	Project	X	X	X	X	P (Center)	X	P (Center)	
	Cost Estimation	15	Project	X	X	X	P (Center)	P (Center)	X	P (Center)	
	Schedule	16	Project	X	X	X	P (Center)		X	P (Center)	
	Training	17	Project	X	X	X			X	P (Center)	
	Reviews	18	Project	X	X	X	X		X	P (Center)	
	Life Cycle	19	Project	X	X	X	P (Center)		X (not OTS)	P (Center)	
	SW Classification	20	Project	X	X	X	X	X	X	X	X
	SW Classification changes	21	Project	X	X	X	X	X	X	X	X
	SW Assurance	22	Project	X (Note 2)	X (Note 2)	P (project)			X	X	
	SW Safety	23	Project	X	X	X	X	X	X	X	X
	Plan Tracking	24	Project	X	X	X	P (Center)		X	P (Center)	
	Corrective Action	25	Project	X	X	X			X	P (Center)	
	Changes	26	Project	X	X	X			X	P (Center)	
Off The Shelf (OTS) SW	*COTS, GOTS, MOTS*	27	Project	X	X	X			X	P (Center)	
Verification & Validation	*Verification planning*	28	Project	X	X	X	P (Center)		X	P (Center)	
	Validation planning	29	Project	X	X	X	P (Center)		X	P (Center)	
	Verification results	30	Project	X	X	X	X		X	P (Center)	
	Validation results	31	Project	X	X	X	X		X	P (Center)	

P (Center): Some part of this requirement is applicable for this Class of S/W - Center defines how it will be implemented

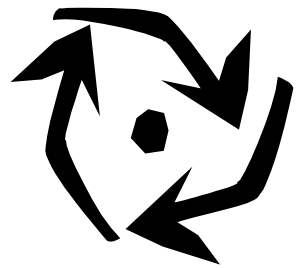
NPR 7150.2 Requirements on Projects

2.1 Compliance With the Law

- **Ensure the laws are implemented**
  - **NPD 2091.1, Inventions Made By Government Employees**
  - **NPR 2190.1, NASA Export Control Program**
  - **NPR 2210.1, External Release of NASA Software**
  - **NPD 2810.1, NASA Information Security Policy**
  - **NPR 3713.1, Procedures for Providing Reasonable Accommodation for Individuals with Disabilities**
  - **Section 508 of the Rehabilitation Act**

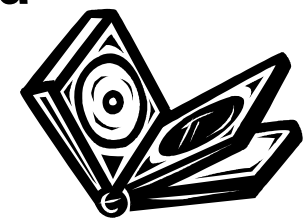
2.2 Software Life Cycle Planning

- Develop and execute a software plan with cost estimates and schedule
- Include performance tracking, status reviews, issue tracking, software assurance, and training for project personnel
- Select and document a software development life cycle or model with phase transition criteria
- Classify each system and subsystem (Class A, B, C, D, E, F, G or H), updating the plan if the classification is elevated
- Ensure that safety requirements of NASA-STD-8719.13, Software Safety, are implemented for safety critical software
- Ensure that corrective actions are taken and managed to closure when performance deviates from the plan
- Ensure that changes to commitments (e.g., software plans) are agreed to by affected stakeholders



Sections 2.3 and 2.4

- **2.3 Commercial, Government, and Modified Off-The-Shelf Software**
  - **Ensure that NPR 7150.2 conditions are satisfied when COTS, GOTS, MOTS, open source, reuse, legacy, or heritage software product is to be acquired**



- **2.4 Software Verification and Validation**
  - **Plan activities, methods, environments, and criteria for software verification and software validation**
  - **Record, address, and track to closure the results of software verification activities and software validation activities**

2.5 Project Formulation Requirements

- Ensure that software is developed by an organization rated at least at CMMI ® -SE/SW Capability Level 2 if Class A or B (and some Class C)*
- Assess acquisition options against evaluation criteria including risk, cost, and benefits
- Define and document acceptance criteria and conditions for the software.
- Establish or identify the procedure for software supplier selection including proposal evaluation criteria
- Determine which software processes, activities, and tasks are appropriate for the project
- Define the milestones at which software supplier's progress will be reviewed and audited as a part of the monitoring of the acquisition
- Document software acquisition planning decisions

*For Class B software, in lieu of a CMMI certifications by a developer, the project will conduct a software capability evaluation in the seven process areas listed in SWE-032 and mitigate any risk, if deficient.

2.6 Software Contract Requirements

- **Require software suppliers to:**
  - **Provide insight into software development and test activities**
  - **Provide software products and software process tracking information in electronic format**
  - **Notify the project in the Proposal if open source software will be included in the delivered code**
  - **Provide electronic access to developed source code**
  - **Track and provide data on all software changes**
  - **Provide software metric data per the project's Software Metrics Report**
  - **Provide software schedule for the project's review**
  - **Provide software traceability data electronically for review**
- **Document in the solicitation the software processes, activities, and tasks to be performed by the supplier**
- **Participate in joint NASA/contractor audits of the software development and configuration management processes**

3.1 Software Requirements

- Identify, develop, document, approve, and maintain software requirements
  - Based on analysis of operational concepts and requirements from the customer and other stakeholders
- Perform software requirements analysis
  - Based on flowed-down and derived requirements from the top-level systems engineering requirements
- Perform, document, and maintain bi-directional traceability between software requirements and higher level requirements
- Collect and manage software requirements changes
- Identify inconsistencies between requirements, project plans, and software products and initiate corrective actions
- Perform requirements validation to ensure S/W will perform as intended in the customer environment

3.2 Software Design

- **Document the software design**
- **Document an architectural design based on allocated and derived requirements**
- **Develop and record a detailed design**
  - **Based on the architectural design**
  - **Describes lower level units so they can be coded, compiled, and tested**
- **Perform and maintain bi-directional traceability between software requirements and software design**

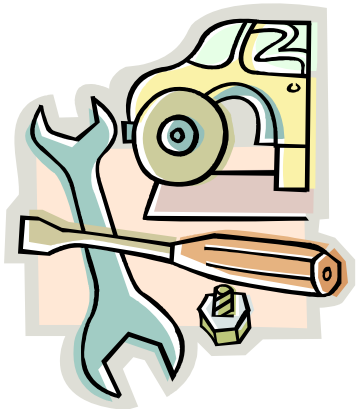
3.3 Software Implementation

- **Implement the software design into software code**
- **Ensure that software coding methods, standards, and/or criteria are adhered to and verified**
- **Provide a Software Version Description document for each software release**
- **Provide and maintain traceability from software design to the software code**

3.4 Software Testing

- Provide test plans, procedures, and reports
- Perform software testing as defined in the Software Test Plan
- Ensure that software implementation is verified to each requirement
- Evaluate test results and document the evaluation
- Document and track to closure all defects identified during testing
- Test, validate, and certify software models, simulations, and analysis tools
- Update Software Test Plans and Software Test Procedures to be consistent with software requirements
- Provide and maintain traceability from Software Test Procedures to software requirements
- Ensure that software systems are validated on targeted platforms or high-fidelity simulators

3.5 Software Operations, Maintenance, and Retirement



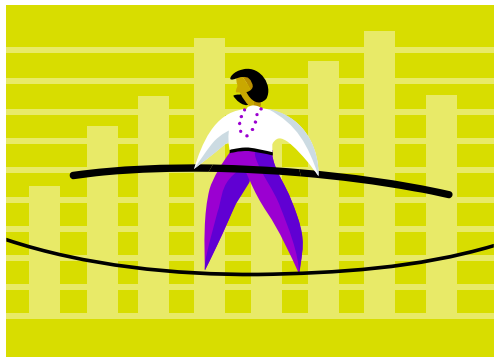
- **Develop a Software Maintenance Plan document**
- **Implement the software operations, maintenance, and retirement activities as defined applicable project plans**
- **Complete and deliver the software product with as-built documentation to support operations and maintenance**

4.1 Software Configuration Management

- Develop a Software Configuration Management Plan*
- Track and evaluate changes to software products
- Identify the software configuration items and their versions to be controlled for the project
- Establish and implement change control procedures
- Prepare and maintain records of the configuration status of configuration items
- Ensure that software configuration audits are performed
- Establish and implement procedures for the storage, handling, delivery, release, and maintenance of deliverable software products

*Can be included in the SMP/PP

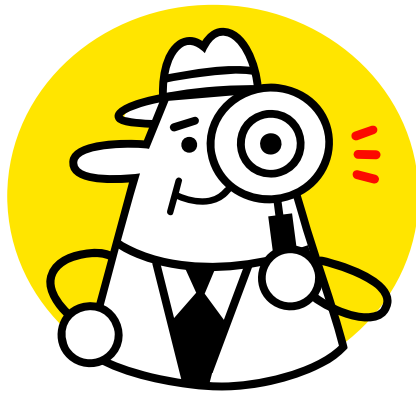
4.2 Risk Management



- **Identify, analyze, plan, track, control, communicate, and document software risks in accordance with**
  - **NPR 7120.5, NASA Program and Project Management Processes and Requirements**
  - **NPR 8000.4, Risk Management Procedural Requirements**

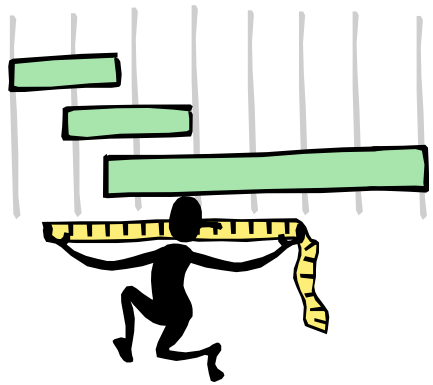
4.3 Peer Reviews/Inspections

- **Ensure peer reviews are performed for Software Requirements, Software Test Plans, and appropriate design and code per the software development plans**
- **Use a checklist to evaluate work products**
  - **Use established readiness and completion criteria**
  - **Track actions identified for each planned peer review to closure**
- **Record basic measurements for each planned peer review**



4.4 Software Measurement

- Establish and document specific project measurement objectives
- Select and record specific measures for:
  - Software progress tracking,
  - Software functionality
  - Software quality
  - Software requirements volatility
  - Software characteristics



- Document and implement data collection and storage procedures for planned software measures
- Analyze software measurement data collected
  - use project and Center/organizational analysis procedures
- Report measurement analysis results periodically
- Allow access to measurement information by Center-defined organizational measurement programs

5.1 Software Plans

- **Develop and document the following plans* satisfying requirements specified in NPR 7150.2, as appropriate**
  - **Software Development or Management Plan**
  - **Software Configuration Management Plan**
  - **Software Test Plan**
  - **Software Maintenance Plan**
- **Develop and document a Software Assurance Plan in accordance with NASA-STD-8739.8, NASA Software Assurance Standard**

* Documents can be combined if required content is addressed.

5.2 Software Requirements and Product Data

- **Develop the following documents with at least the minimum requirements specified in NPR 7150.2, as appropriate***
  - **Software Requirements Specification**
  - **Software Data Dictionary**
  - **Software Design Description**
  - **Interface Design Description**
  - **Software Change Request/Problem Report**
  - **Software Test Procedures**
  - **Software User Manual**
  - **Software Version Description**

Notes:

- **The specific contents of these documents required by the NPR vary by software Class**
- **Center requirements may also specify contents for some classes**
- **Some software classes not required to have all documents**

Sections 5.3 and 6.3

- **5.3 Software Report Requirements**
  - **Develop the following reports with at least the minimum requirements specified in NPR 7150.2, as appropriate**
    - Software Metrics Report, by CSCI
    - Software Test Report
    - Software Inspection/Peer Review Report
- **6.3 Compliance**
  - **Maintain a compliance matrix against requirements in NPR 7150.2, including those delegated to other parties or accomplished by contract vehicles**

Don’t Panic!….

- **Many have preceded you on the journey and have left “breadcrumbs” behind**
  - **There are tools, procedures, boilerplate, and data in the NASA legacy programs already in existence to get you started on most of this stuff.**
- **If you have questions about NPR 7150.2 and how it applies to your project consult the following resources:**
  - **NPR 7150.2 FAQ:**
    - Go to http://software.nasa.gov
    - Select "frequently asked questions" under NPR 7150.2
  - **GSFC SPI**
    - is available to help you interpret NPR 7150.2
    - provides compliant tools, procedures, and techniques
  - **GSFC Software Engineering Process Group (SEPG)**
    - Sally Godfrey (Sara.H.Godfrey@nasa.gov)
    - Sue Sekira (Susan.J.Sekira@nasa.gov)
  - **S/W Lead at the NASA Office of the Chief Engineer**

A Word About Enforcement

- **NASA Centers are subject to IPS* Compliance Audits of their Software Projects.**
  - **As these requirements mature, expect increasing audit activity**
  - **An audit is planned within the year**

Institutional Programmatic Support

Summary

Summary

- Requirements levied on projects are mandatory unless a waiver is requested and granted by the ITA Warrant Authority
- NPR 7150.2 should be reviewed and requirements incorporated in project planning activities
- Requirements vary by project based on software classification
  - See Appendix D to determine requirements based on Software Class
- *NPR 7150.2 requirements are consistent with CMMI ® - SE/SW Capability Level 2 for Class A, B, C*

Questions?

Acronyms

- CMM – Capability Maturity Model
- CMMI – Capability Maturity Model Integrated
- COTS – Commercial Off-the-Shelf
- CSCI – Computer Software Configuration Item
- GOTS – Government Off-the-Shelf
- IPS – Institutional Programmatic Support
- ITA – Independent Technical Authority
- MOTS – Modified Off-the-Shelf
- NODIS – NASA Online Directives Information System
- NPD – NASA Policy Directive
- NPR – NASA Procedural Requirement
- SEPG – Software Engineering Process Group
- SE/SW – System Engineering/Software
- SPI – Software Process Improvement